Investigation into Interference Potential of Ultrawideband Signals

Outputs

- Methods developed and measurements performed to determine UWB interference susceptibility of C-band satellite digital television receivers.
- Measurements performed to determine the effects of gating on the interference potential of Gaussian noise.
- Comparative measurements and analysis of DS-UWB and MB-OFDM signals.
- IEEE 802.15.3a standards contribution.

On March 22, 2004, ITS entered into a cooperative research and development agreement with Motorola/ Freescale Inc. A primary goal of this research is to identify characteristics of various ultrawideband (UWB) waveforms that correlate with performance degradation of legacy victim receivers.

UWB interference provides a unique challenge for spectrum policy makers. Narrow pulses, inherent to "conventional" UWB signals, spread power across a frequency band that can simultaneously cover operational bands for a number of victim receivers. UWB proponents have argued that UWB power spectral density is below the noise threshold of narrowband receivers and therefore causes little interference. UWB opponents argue that proliferation of UWB consumer devices will create a significantly degraded radio environment due to increased power spectral density of aggregate UWB interference and increased probability of encountering UWB devices.

In 2002, the Federal Communications Commission permitted low-power UWB emissions between 3.1 GHz and 10.6 GHz. The rules require that UWB signals have a 10-dB bandwidth greater than 500 MHz and greater than 25% of the center frequency without specifying how that bandwidth is achieved (i.e., which modulation is used). Consequently, these regulations expanded the scope of UWB to include modulations with defined carriers and band-limited pulses in addition to "conventional" carrier-less UWB signals.

An example of the increased scope of UWB is the development of the multi-band orthogonal frequency-division multiplexing (MB-OFDM) technology for short range, high data rate wireless communications. MB-OFDM achieves the ultra-wide bandwidth criteria with a 528-MHz wide OFDM signal that hops between 14 different bands. Direct-sequence ultrawideband (DS-UWB) is another technology recently developed for short-range wireless communications that combines conventional spread spectrum techniques and pulse shaping. Figures 1 and 2 illustrate amplitude statistics of simulated DS-UWB and MB-OFDM signals in various limiting bandwidths.

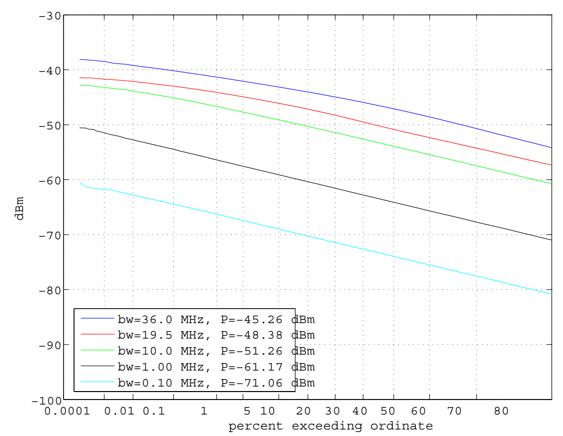

Figure 1. Amplitude statistics of DS-UWB (code = 0, -1, -1, -1, 1, 1, 1, -1, 1, 1, -1, 1).

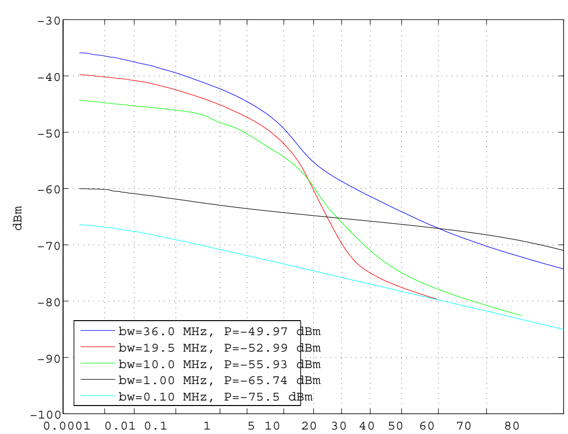

Figure 2. Amplitude statistics of MB-OFDM that hops between three bands and dwells at each band for a single MB-OFDM word (312.5 nanoseconds).

Figure 3. Test set-up (photograph by F.H. Sanders).

Proponents of DS-UWB and MB-OFDM both seek standardization from IEEE 802.15 working group 3a on high-rate (greater than 20 million bits per second) wireless personal area networks (WPAN). As the name implies, WPAN is intended for short-distance (<10 meters) wireless networking of portable and mobile computing devices, e.g., PCs, personal digital assistants, digital cameras, mobile phones, and other consumer electronics. The standards process has reached a stalemate. At the heart of the issue lie fundamental questions regarding the interference UWB devices impose on legacy victim receivers.

This study was intended to address UWB interference issues and provide scientific answers to the following questions: (1) Which type of modulation, DS-UWB or MB-OFDM, causes the most performance degradation to victim receivers? (2) Do existing FCC compliance metrics and measurement procedures adequately predict performance degradation due to UWB interference? To get at these questions ITS focused on a single victim receiver, C-band satellite digital television.

C-band satellite television receivers provide an excellent victim receiver to be tested for UWB interference susceptibility because: (1) the operational frequency band (3.7–4.2 GHz) lies within the band allocated for UWB emissions; (2) signals transmitted by satellites are weak at Earth stations, making them vulnerable to interference; and (3) satellite television broadcast technologies cover a broad range of communications techniques (analog and digital) and signal processing concepts (modulation, multiplexing, error correction, interleaving, encryption) allowing for a number of operational scenarios to be investigated.

In this study, ITS attempted to identify measurable interference metrics that correlate with performance degradation in C-band satellite receivers. Toward this end, we developed procedures for characterization of signals representative of existing and proposed UWB systems. Additionally, we designed a conducted experiment comprised of a satellite signal simulator, interference generation by a Vector Signal Generator, and performance monitoring of the victim receiver via an MPEG transport stream monitor.

Additional information may be found at: www.its.bldrdoc.gov/home/programs/uwb_interference/.

Recent Contribution

IEEE 802.15.3a standards contribution, "Estimating and Graphing the Amplitude Probability Distribution Function of Complex-Baseband Signals," by R. Achatz, M. Cotton, and R. Dalke.

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